

# Appendix A

## Thermal Conversion Factors

### Using Thermal Conversion Factors

The thermal conversion factors presented in the following six tables can be used to estimate the heat content in British thermal units (Btu) of a given amount of energy measured in physical units, such as barrels or cubic feet. For example, 10 barrels of asphalt has a heat content of approximately 66.36 million Btu (10 barrels x 6.636 million Btu per barrel = 66.36 million Btu).

In general, the annual thermal conversion factors presented in Tables A2 through A6 are computed from final annual data. However, if the current year's final data are not available in time for publication, thermal conversion factors for the current year are computed from the best available data and are labeled "preliminary." Usually, the previous year's factor is used as the preliminary value until data become available to calculate the factor appropriate to the year. The source of each factor is described in the section entitled "Thermal Conversion Factor Source Documentation," which follows Table A6 in this appendix.

Thermal conversion factors for hydrocarbon mixes are weighted averages of the thermal conversion factors for each hydrocarbon included in the mix. For example, in calculating the thermal conversion factor for a 60-40 butane-propane mixture, the thermal conversion factor for butane is weighted 1.5 times the thermal conversion factor for propane.

More information about British thermal units (the standardized unit of measure for energy) can be found in the Glossary.

**Table A1. Approximate Heat Content of Petroleum Products**  
(Million Btu per Barrel)

Energy Source	Heat Content
Asphalt .....	6.636
Aviation Gasoline .....	5.048
Butane .....	4.326
Butane-Propane Mixture (60 percent-40 percent) .....	4.130
Distillate Fuel Oil .....	5.825
Ethane .....	3.082
Ethane-Propane Mixture (70 percent-30 percent) .....	3.308
Isobutane .....	3.974
Jet Fuel, Kerosene-Type .....	5.670
Jet Fuel, Naphtha-Type .....	5.355
Kerosene .....	5.670
Lubricants .....	6.065
Motor Gasoline, Conventional .....	5.253
Motor Gasoline, Oxygenated .....	5.150
Motor Gasoline, Reformulated .....	5.150
Natural Gasoline .....	4.620
Pentanes Plus .....	4.620
Petrochemical Feedstocks	
Naphtha less than 401° F .....	5.248
Other Oils equal to or greater than 401° F .....	5.825
Still Gas .....	6.000
Petroleum Coke .....	6.024
Plant Condensate .....	5.418
Propane .....	3.836
Residual Fuel Oil .....	6.287
Road Oil .....	6.636
Special Naphthas .....	5.248
Still Gas .....	6.000
Unfinished Oils .....	5.825
Unfractionated Stream .....	5.418
Waxes .....	5.537
Miscellaneous .....	5.796

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A2. Approximate Heat Content of Crude Oil, Crude Oil and Products, and Natural Gas Plant Liquids, 1949-1999**  
(Million Btu per Barrel)

Year	Crude Oil Only			Crude Oil and Products		Natural Gas Plant Liquids Production
	Production	Imports	Exports	Imports	Exports	
1949	5.800	5.952	5.800	6.059	5.692	4.544
1950	5.800	5.943	5.800	6.080	5.766	4.522
1951	5.800	5.938	5.800	6.075	5.762	4.495
1952	5.800	5.938	5.800	6.067	5.774	4.464
1953	5.800	5.924	5.800	6.052	5.742	4.450
1954	5.800	5.931	5.800	6.052	5.745	4.415
1955	5.800	5.924	5.800	6.040	5.768	4.406
1956	5.800	5.916	5.800	6.024	5.754	4.382
1957	5.800	5.918	5.800	6.023	5.780	4.369
1958	5.800	5.916	5.800	5.993	5.779	4.366
1959	5.800	5.916	5.800	6.020	5.829	4.311
1960	5.800	5.911	5.800	6.021	5.834	4.295
1961	5.800	5.900	5.800	5.991	5.832	4.283
1962	5.800	5.890	5.800	6.004	5.841	4.273
1963	5.800	5.894	5.800	6.002	5.840	4.264
1964	5.800	5.882	5.800	5.998	5.844	4.268
1965	5.800	5.872	5.800	5.997	5.743	4.264
1966	5.800	5.863	5.800	5.993	5.729	4.259
1967	5.800	5.838	5.800	5.999	5.777	4.232
1968	5.800	5.836	5.800	5.977	5.763	4.218
1969	5.800	5.825	5.800	5.974	5.714	4.170
1970	5.800	5.822	5.800	5.985	5.810	4.146
1971	5.800	5.824	5.800	5.961	5.775	4.117
1972	5.800	5.809	5.800	5.935	5.741	4.070
1973	5.800	5.817	5.800	5.897	5.752	4.049
1974	5.800	5.827	5.800	5.884	5.774	4.011
1975	5.800	5.821	5.800	5.858	5.748	3.984
1976	5.800	5.808	5.800	5.856	5.745	3.964
1977	5.800	5.810	5.800	5.834	5.797	3.941
1978	5.800	5.802	5.800	5.839	5.808	3.925
1979	5.800	5.810	5.800	5.810	5.832	3.955
1980	5.800	5.812	5.800	5.796	5.820	3.914
1981	5.800	5.818	5.800	5.775	5.821	3.930
1982	5.800	5.826	5.800	5.775	5.820	3.872
1983	5.800	5.825	5.800	5.774	5.800	3.839
1984	5.800	5.823	5.800	5.745	5.850	3.812
1985	5.800	5.832	5.800	5.736	5.814	3.815
1986	5.800	5.903	5.800	5.808	5.832	3.797
1987	5.800	5.901	5.800	5.820	5.858	3.804
1988	5.800	5.900	5.800	5.820	5.840	3.800
1989	5.800	5.906	5.800	5.833	5.857	3.826
1990	5.800	5.934	5.800	5.849	5.833	3.822
1991	5.800	5.948	5.800	5.873	5.823	3.807
1992	5.800	5.953	5.800	5.877	5.777	3.804
1993	5.800	5.954	5.800	5.883	5.779	3.801
1994	5.800	5.950	5.800	5.861	<sup>R</sup> 5.779	3.794
1995	5.800	5.924	5.800	<sup>R</sup> 5.848	<sup>R</sup> 5.747	3.796
1996	5.800	5.935	5.800	<sup>R</sup> 5.842	<sup>R</sup> 5.741	3.777
1997	5.800	5.954	5.800	<sup>R</sup> 5.862	<sup>R</sup> 5.729	3.762
1998	5.800	<sup>R</sup> 5.953	5.800	5.862	<sup>R</sup> 5.715	<sup>R</sup> 3.769
1999 <sup>P</sup>	5.800	5.941	5.800	5.850	5.715	3.745

R=Revised. P=Preliminary.  
Note: Crude oil includes lease condensate.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A3. Approximate Heat Content of Petroleum Product Weighted Averages, 1949-1999**  
(Million Btu per Barrel)

Year	Consumption					Imports	Exports	Liquefied Petroleum Gases Consumption	Motor Gasoline Consumption
	Residential and Commercial	Industrial	Transportation	Electric Utilities	Total				
1949	5.631	5.947	5.465	6.254	5.649	6.261	5.651	4.011	5.253
1950	5.626	5.940	5.461	6.254	5.649	6.263	5.751	4.011	5.253
1951	5.626	5.913	5.458	6.254	5.634	6.265	5.753	4.011	5.353
1952	5.621	5.905	5.442	6.254	5.621	6.261	5.768	4.011	5.253
1953	5.606	5.897	5.426	6.254	5.608	6.268	5.732	4.011	5.253
1954	5.603	5.883	5.412	6.254	5.595	6.252	5.738	4.011	5.253
1955	5.607	5.866	5.408	6.254	5.591	6.234	5.765	4.011	5.253
1956	5.601	5.856	5.406	6.254	5.585	6.225	5.744	4.011	5.253
1957	5.587	5.842	5.405	6.254	5.577	6.219	5.774	4.011	5.253
1958	5.582	5.832	5.393	6.254	5.567	6.091	5.778	4.011	5.253
1959	5.549	5.811	5.389	6.254	5.557	6.142	5.830	4.011	5.253
1960	5.570	5.800	5.388	6.267	5.555	6.161	5.835	4.011	5.253
1961	5.570	5.795	5.386	6.268	5.552	6.102	5.833	4.011	5.253
1962	5.555	5.784	5.386	6.267	5.545	6.138	5.842	4.011	5.253
1963	5.532	5.759	5.384	6.266	5.534	6.126	5.841	4.011	5.253
1964	5.517	5.728	5.388	6.267	5.528	6.129	5.845	4.011	5.253
1965	5.535	5.728	5.387	6.267	5.532	6.123	5.742	4.011	5.253
1966	5.523	5.722	5.388	6.266	5.532	6.112	5.728	4.011	5.253
1967	5.473	5.682	5.391	6.266	5.515	6.128	5.758	3.838	5.253
1968	5.450	5.646	5.394	6.263	5.504	6.095	5.762	3.818	5.253
1969	5.399	5.603	5.394	6.259	5.492	6.093	5.713	3.805	5.253
1970	5.404	5.604	5.393	6.252	5.503	6.088	5.811	3.779	5.253
1971	5.392	5.600	5.389	6.245	5.504	6.062	5.775	3.772	5.253
1972	5.368	5.564	5.388	6.233	5.500	6.045	5.741	3.760	5.253
1973	5.387	5.568	5.395	6.245	5.515	5.983	5.752	3.746	5.253
1974	5.377	5.538	5.394	6.238	5.504	5.959	5.773	3.730	5.253
1975	5.358	5.528	5.392	6.250	5.494	5.935	5.747	3.715	5.253
1976	5.383	5.538	5.395	6.251	5.504	5.980	5.743	3.711	5.253
1977	5.389	5.555	5.400	6.249	5.518	5.908	5.796	3.677	5.253
1978	5.382	5.553	5.404	6.251	5.519	5.955	5.814	3.669	5.253
1979	5.471	5.418	5.428	6.258	5.494	5.811	5.864	3.680	5.253
1980	5.468	5.376	5.440	6.254	5.479	5.748	5.841	3.674	5.253
1981	5.409	5.313	5.432	6.258	5.448	5.659	5.837	3.643	5.253
1982	5.392	5.263	5.422	6.258	5.415	5.664	5.829	3.615	5.253
1983	5.286	5.273	5.415	6.255	5.406	5.677	5.800	3.614	5.253
1984	5.384	5.223	5.422	6.251	5.395	5.613	5.867	3.599	5.253
1985	5.326	5.221	5.423	6.247	5.387	5.572	5.819	3.603	5.253
1986	5.357	5.286	5.427	6.257	5.418	5.624	5.839	3.640	5.253
1987	5.316	5.253	5.430	6.249	5.403	5.599	5.860	3.659	5.253
1988	5.320	5.248	5.434	6.250	5.410	5.618	5.842	3.652	5.253
1989	5.257	5.233	5.440	6.241	5.410	5.641	5.869	3.683	5.253
1990	5.208	5.272	5.445	6.247	5.411	5.614	5.838	3.625	5.253
1991	5.163	5.192	5.442	6.248	5.384	5.636	5.827	3.614	5.253
1992	5.169	5.188	5.445	6.243	5.378	5.623	5.774	3.624	5.253
1993	5.148	5.200	5.438	6.241	5.379	5.620	5.777	3.606	5.253
1994	5.154	R5.170	R5.427	6.231	R5.361	R5.534	R5.777	3.635	25.230
1995	5.126	R5.139	R5.419	6.210	R5.341	R5.504	R5.741	3.623	5.215
1996	R5.101	R5.125	R5.421	6.212	R5.336	R5.489	R5.733	3.613	5.216
1997	5.076	R5.134	R5.417	6.220	R5.336	R5.472	R5.720	3.616	5.213
1998	R5.045	R5.154	R5.415	R6.220	R5.349	R5.465	R5.704	R3.614	5.212
1999 <sup>P</sup>	5.003	5.098	5.419	6.207	5.328	5.453	5.703	3.616	5.212

<sup>1</sup> There is a discontinuity in this time series between 1966 and 1967; beginning in 1967, the single constant factor is replaced by a quantity-weighted average of liquefied petroleum gases' major components.

<sup>2</sup> There is a discontinuity in this time series between 1993 and 1994; beginning in 1994, the single constant factor is replaced by a factor that is a quantity-weighted average of motor gasoline's major components. See Table A1.

R=Revised. P=Preliminary.

Note: Weighted averages of the products included in each category are calculated by using heat content values shown in Table A1.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A4. Approximate Heat Content of Natural Gas, 1949-1999**  
(Btu per Cubic Foot)

Year	Production		Consumption			Imports	Exports
	Dry	Marketed	Sectors Other Than Electric Utilities	Electric Utilities	Total		
1949	1,035	1,120	1,035	1,035	1,035	—	1,035
1950	1,035	1,119	1,035	1,035	1,035	—	1,035
1951	1,035	1,114	1,035	1,035	1,035	—	1,035
1952	1,035	1,115	1,035	1,035	1,035	1,035	1,035
1953	1,035	1,116	1,035	1,035	1,035	1,035	1,035
1954	1,035	1,115	1,035	1,035	1,035	1,035	1,035
1955	1,035	1,120	1,035	1,035	1,035	1,035	1,035
1956	1,035	1,116	1,035	1,035	1,035	1,035	1,035
1957	1,035	1,113	1,035	1,035	1,035	1,035	1,035
1958	1,035	1,110	1,035	1,035	1,035	1,035	1,035
1959	1,035	1,109	1,035	1,035	1,035	1,035	1,035
1960	1,035	1,107	1,035	1,035	1,035	1,035	1,035
1961	1,035	1,108	1,035	1,035	1,035	1,035	1,035
1962	1,035	1,107	1,035	1,035	1,035	1,035	1,035
1963	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1964	1,032	1,102	1,032	1,032	1,032	1,032	1,032
1965	1,032	1,101	1,032	1,032	1,032	1,032	1,032
1966	1,033	1,103	1,033	1,033	1,033	1,033	1,033
1967	1,032	1,105	1,032	1,032	1,032	1,032	1,032
1968	1,031	1,115	1,031	1,031	1,031	1,031	1,031
1969	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1970	1,031	1,102	1,031	1,031	1,031	1,031	1,031
1971	1,031	1,103	1,031	1,031	1,031	1,031	1,031
1972	1,027	1,100	1,027	1,027	1,027	1,027	1,027
1973	1,021	1,093	1,020	1,024	1,021	1,026	1,023
1974	1,024	1,097	1,024	1,022	1,024	1,027	1,016
1975	1,021	1,095	1,020	1,026	1,021	1,026	1,014
1976	1,020	1,093	1,019	1,023	1,020	1,025	1,013
1977	1,021	1,093	1,019	1,029	1,021	1,026	1,013
1978	1,019	1,088	1,016	1,034	1,019	1,030	1,013
1979	1,021	1,092	1,018	1,035	1,021	1,037	1,013
1980	1,026	1,098	1,024	1,035	1,026	1,022	1,013
1981	1,027	1,103	1,025	1,035	1,027	1,014	1,011
1982	1,028	1,107	1,026	1,036	1,028	1,018	1,011
1983	1,031	1,115	1,031	1,030	1,031	1,024	1,010
1984	1,031	1,109	1,030	1,035	1,031	1,005	1,010
1985	1,032	1,112	1,031	1,038	1,032	1,002	1,011
1986	1,030	1,110	1,029	1,034	1,030	997	1,008
1987	1,031	1,112	1,031	1,032	1,031	999	1,011
1988	1,029	1,109	1,029	1,028	1,029	1,002	1,018
1989	1,031	1,107	1,031	1,030	1,031	1,004	1,019
1990	1,031	1,106	1,030	1,034	1,031	1,012	1,018
1991	1,030	1,108	1,031	1,024	1,030	1,014	1,022
1992	1,030	1,110	1,031	1,022	1,030	1,011	1,018
1993	1,027	1,106	1,028	1,022	1,027	1,020	1,016
1994	1,028	1,105	1,029	1,022	1,028	1,022	1,011
1995	1,027	1,106	1,027	1,025	1,027	1,021	1,011
1996	1,027	1,109	1,027	1,024	1,027	1,022	1,011
1997	1,026	1,107	1,027	1,019	1,026	1,023	1,011
1998	R1,031	R1,110	R1,033	R1,022	R1,031	1,023	1,011
1999 <sup>P</sup>	1,031	1,110	1,033	1,022	1,031	1,023	1,011

R=Revised. P=Preliminary. — = Not applicable.

Source: See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A5. Approximate Heat Content of Coal and Coal Coke, 1949-1999**

(Million Btu per Short Ton)

Year	Coal									Coal Coke			
	Production	Consumption						Imports	Exports	Imports and Exports			
		End-Use Sectors			Electric Power Sector		Total						
		Residential and Commercial	Industrial		Electric Utilities	Other Power Producers <sup>2</sup>							
			Coke Plants	Other <sup>1</sup>									
1949	24.916	24.263	26.797	24.612	23.761	NA	24.793	25.000	26.759	24.800			
1950	25.090	24.461	26.798	24.820	23.937	NA	24.989	25.020	26.788	24.800			
1951	25.019	24.281	26.796	24.521	23.701	NA	24.813	25.034	26.848	24.800			
1952	25.096	24.371	26.796	24.724	23.885	NA	24.901	25.040	26.859	24.800			
1953	25.147	24.383	26.796	24.785	23.964	NA	25.006	25.048	26.881	24.800			
1954	25.054	24.362	26.795	24.788	23.996	NA	24.913	25.012	26.865	24.800			
1955	25.201	24.373	26.794	24.821	24.056	NA	24.982	25.000	26.907	24.800			
1956	25.117	24.195	26.792	24.664	23.943	NA	24.843	25.000	26.886	24.800			
1957	25.213	24.238	26.792	24.707	23.980	NA	24.905	25.001	26.914	24.800			
1958	24.983	24.287	26.794	24.606	23.897	NA	24.716	25.005	26.931	24.800			
1959	24.910	24.224	26.790	24.609	23.924	NA	24.719	25.003	26.927	24.800			
1960	24.906	24.226	26.791	24.609	23.927	NA	24.713	25.003	26.939	24.800			
1961	24.849	24.248	26.792	24.580	23.904	NA	24.653	25.002	26.937	24.800			
1962	24.828	24.173	26.788	24.562	23.911	NA	24.627	25.013	26.928	24.800			
1963	24.831	24.033	26.784	24.509	23.897	NA	24.588	25.007	26.894	24.800			
1964	24.840	24.037	26.785	24.477	23.864	NA	24.602	25.000	26.949	24.800			
1965	24.775	24.028	26.787	24.385	23.780	NA	24.537	25.000	26.973	24.800			
1966	24.629	23.915	26.786	24.226	23.648	NA	24.396	25.000	26.976	24.800			
1967	24.475	23.685	26.781	24.040	23.506	NA	24.243	25.000	26.981	24.800			
1968	24.445	23.621	26.780	24.014	23.486	NA	24.186	25.000	26.984	24.800			
1969	24.280	23.474	26.779	23.724	23.240	NA	23.976	25.000	26.982	24.800			
1970	23.842	23.203	26.784	22.983	22.573	NA	23.440	25.000	26.982	24.800			
1971	23.507	23.090	26.784	22.670	22.301	NA	23.124	25.000	26.981	24.800			
1972	23.389	22.998	26.782	22.550	22.204	NA	23.036	25.000	26.979	24.800			
1973	23.376	22.831	26.780	22.586	22.246	NA	23.057	25.000	26.596	24.800			
1974	23.072	22.479	26.778	22.419	21.781	NA	22.677	25.000	26.700	24.800			
1975	22.897	22.261	26.782	22.436	21.642	NA	22.506	25.000	26.562	24.800			
1976	22.855	22.774	26.781	22.530	21.679	NA	22.498	25.000	26.601	24.800			
1977	22.597	22.919	26.787	22.322	21.508	NA	22.265	25.000	26.548	24.800			
1978	22.248	22.466	26.789	22.207	21.275	NA	22.017	25.000	26.478	24.800			
1979	22.454	22.242	26.788	22.452	21.364	NA	22.100	25.000	26.548	24.800			
1980	22.415	22.543	26.790	22.690	21.295	NA	21.947	25.000	26.384	24.800			
1981	22.308	22.474	26.794	22.585	21.085	NA	21.713	25.000	26.160	24.800			
1982	22.239	22.695	26.797	22.712	21.194	NA	21.674	25.000	26.223	24.800			
1983	22.052	22.775	26.798	22.691	21.133	NA	21.576	25.000	26.291	24.800			
1984	22.010	22.844	26.799	22.543	21.101	NA	21.573	25.000	26.402	24.800			
1985	21.870	22.646	26.798	22.020	20.959	NA	21.366	25.000	26.307	24.800			
1986	21.913	22.947	26.798	22.198	21.084	NA	21.462	25.000	26.292	24.800			
1987	21.922	23.404	26.799	22.381	21.136	NA	21.517	25.000	26.291	24.800			
1988	21.823	23.571	26.799	22.360	20.900	NA	21.328	25.000	26.299	24.800			
1989	21.765	23.650	26.800	22.347	20.848	NA	21.272	25.000	26.160	24.800			
1990	21.822	23.137	26.799	22.457	20.929	NA	21.331	25.000	26.202	24.800			
1991	21.681	23.114	26.799	22.460	20.755	NA	21.146	25.000	26.188	24.800			
1992	21.682	23.105	26.799	22.250	20.787	18.928	21.107	25.000	26.161	24.800			
1993	21.418	22.994	26.800	22.123	20.639	18.995	20.947	25.000	26.335	24.800			
1994	21.394	23.112	26.800	22.068	20.673	19.450	20.978	25.000	26.329	24.800			
1995	21.326	23.118	26.800	21.950	20.495	19.417	20.814	25.000	26.180	24.800			
1996	21.322	23.011	26.800	22.105	20.525	19.391	20.824	25.000	26.174	24.800			
1997	21.296	22.494	26.800	22.172	20.548	19.596	20.835	25.000	26.251	24.800			
1998	<sup>R</sup> 21.224	<sup>R</sup> 22.783	26.800	<sup>R</sup> 22.104	<sup>R</sup> 20.479	<sup>R</sup> 20.143	<sup>R</sup> 20.760	25.000	<sup>R</sup> 26.243	24.800			
1999 <sup>P</sup>	21.224	22.783	26.800	22.104	20.479	20.143	20.760	25.000	26.243	24.800			

<sup>1</sup> Includes transportation.<sup>2</sup> Nonutility wholesale producers of electricity, and nonutility cogeneration plants that are not included in the end-use sectors.

R=Revised. P=Preliminary. NA=Not available.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels. See "Thermal Conversion Factor Source Documentation," which follows Table A6.

**Table A6. Approximate Heat Rates for Electricity, 1949-1999**  
(Btu per Kilowatthour)

Year	Electricity Generation			Electricity Consumption
	Fossil-Fueled Steam-Electric Plants <sup>1</sup>	Nuclear Steam-Electric Plants	Geothermal Energy Plants <sup>2</sup>	
1949	15,033	—	—	3,412
1950	14,030	—	—	3,412
1951	13,641	—	—	3,412
1952	13,361	—	—	3,412
1953	12,889	—	—	3,412
1954	12,180	—	—	3,412
1955	11,699	—	—	3,412
1956	11,456	—	—	3,412
1957	11,365	11,629	—	3,412
1958	11,085	11,629	—	3,412
1959	10,970	11,629	—	3,412
1960	10,760	11,629	23,200	3,412
1961	10,650	11,629	23,200	3,412
1962	10,558	11,629	23,200	3,412
1963	10,482	11,877	22,182	3,412
1964	10,462	11,912	22,182	3,412
1965	10,453	11,804	22,182	3,412
1966	10,415	11,623	22,182	3,412
1967	10,432	11,555	21,770	3,412
1968	10,398	11,297	21,606	3,412
1969	10,447	11,037	21,606	3,412
1970	10,494	10,977	21,606	3,412
1971	10,478	10,837	21,655	3,412
1972	10,379	10,792	21,668	3,412
1973	10,389	10,903	21,674	3,412
1974	10,442	11,161	21,674	3,412
1975	10,406	11,013	21,611	3,412
1976	10,373	11,047	21,611	3,412
1977	10,435	10,769	21,611	3,412
1978	10,361	10,941	21,611	3,412
1979	10,353	10,879	21,545	3,412
1980	10,388	10,908	21,639	3,412
1981	10,453	11,030	21,639	3,412
1982	10,454	11,073	21,629	3,412
1983	10,520	10,905	21,290	3,412
1984	10,440	10,843	21,303	3,412
1985	10,447	10,813	21,263	3,412
1986	10,446	10,799	21,263	3,412
1987	10,419	10,776	21,263	3,412
1988	10,324	10,743	21,096	3,412
1989	10,432	10,724	21,096	3,412
1990	10,402	10,680	21,096	3,412
1991	10,436	10,740	20,997	3,412
1992	10,342	10,678	20,914	3,412
1993	10,309	10,682	20,914	3,412
1994	10,316	10,676	20,914	3,412
1995	10,312	10,658	20,914	3,412
1996	<sup>R</sup> 10,340	10,623	20,960	3,412
1997	<sup>R</sup> 10,357	10,623	20,960	3,412
1998	<sup>R</sup> 10,346	10,623	<sup>R</sup> 21,017	3,412
1999 <sup>P</sup>	10,346	10,623	21,017	3,412

<sup>1</sup> Used as the thermal conversion factor for hydroelectric power generation, and for wood and waste, wind, and solar energy consumed at electric utilities.

<sup>2</sup> Used as the thermal conversion factor for geothermal energy consumed at electric utilities.

R=Revised data. P=Preliminary data. — = Not applicable.

Source: See "Thermal Conversion Factor Source Documentation," which follows this table.

# Thermal Conversion Factor Source Documentation

## Approximate Heat Content of Petroleum and Natural Gas Plant Liquids

**Asphalt.** The Energy Information Administration (EIA) adopted the thermal conversion factor of 6.636 million British thermal units (Btu) per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Aviation Gasoline.** EIA adopted the thermal conversion factor of 5.048 million Btu per barrel as adopted by the Bureau of Mines from the Texas Eastern Transmission Corporation publication *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.

**Butane.** EIA adopted the Bureau of Mines thermal conversion factor of 4.326 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Butane-Propane Mixture.** EIA adopted the Bureau of Mines calculation of 4.130 million Btu per barrel based on an assumed mixture of 60 percent butane and 40 percent propane. See **Butane** and **Propane**.

**Crude Oil, Exports.** Assumed by EIA to be 5.800 million Btu per barrel or equal to the thermal conversion factor for crude oil produced in the United States. See **Crude Oil** and **Lease Condensate, Production**.

**Crude Oil, Imports.** Calculated annually by EIA by weighting the thermal conversion factor of each type of crude oil imported by the quantity imported. Thermal conversion factors for each type were calculated on a foreign country basis, by determining the average American Petroleum Institute (API) gravity of crude imported from each foreign country from Form ERA-60 in 1977 and converting average API gravity to average Btu content by using National Bureau of Standards, Miscellaneous Publication No. 97, *Thermal Properties of Petroleum Products*, 1933.

**Crude Oil and Lease Condensate, Production.** EIA adopted the thermal conversion factor of 5.800 million Btu per barrel as reported in a Bureau of

Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Crude Oil and Petroleum Products, Exports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product exported and crude oil exported weighted by the quantity of each petroleum product and crude oil exported. See **Crude Oil, Exports** and **Exports Petroleum Products**.

**Crude Oil and Petroleum Products, Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product and each crude oil imported weighted by the quantity of each petroleum product and each type of crude oil imported. See **Crude Oil, Imports** and **Petroleum Products, Imports**.

**Distillate Fuel Oil.** EIA adopted the Bureau of Mines thermal conversion factor of 5.825 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Ethane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.082 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Ethane-Propane Mixture.** EIA calculation of 3.308 million Btu per barrel based on an assumed mixture of 70 percent ethane and 30 percent propane. See **Ethane** and **Propane**.

**Isobutane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.974 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Jet Fuel, Kerosene Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel for “Jet Fuel, Commercial” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.

**Jet Fuel, Naphtha Type.** EIA adopted the Bureau of Mines thermal conversion factor of 5.355 million Btu per barrel for “Jet Fuel, Military” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics.

**Kerosene.** EIA adopted the Bureau of Mines thermal conversion factor of 5.670 million Btu per barrel as reported in a Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.”

**Liquefied Petroleum Gases (LPG) Consumption.** Ethane, ethylene, propane, propylene, normal butane, butylene, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate new natural gas plants liquids.

**Lubricants.** EIA adopted the thermal conversion factor of 6.065 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Miscellaneous Products.** EIA adopted the thermal conversion factor of 5.796 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Motor Gasoline.** EIA adopted the Bureau of Mines thermal conversion factor of 5.253 million Btu per barrel for “Gasoline, Motor Fuel” as published by the Texas Eastern Transmission Corporation in the report *Competition and Growth in American Energy Markets 1947-1985*, a 1968 release of historical and projected statistics. Conversion factors for reformulated and oxygenated motor gasolines are calculated by EIA based on data published in the Environmental Protection Agency, Office of Mobile Sources, National Vehicle and Fuel Emissions Laboratory report EPA 420-F-95-003 *Fuel Economy Impact Analysis of Reformulated Gasoline*. Both of the factors are currently 5.150 million Btu per barrel.

**Natural Gas Plant Liquids, Production.** Calculated annually by EIA as the average of the thermal conversion factors of each natural gas plant liquid produced, weighted by the quantity of each natural gas plant liquid produced.

**Natural Gasoline.** EIA adopted the thermal conversion factor of 4.620 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

**Pentanes Plus.** EIA assumed the thermal conversion factor to be 4.620 million Btu or equal to that for natural gasoline. See **Natural Gasoline**.

**Petrochemical Feedstocks, Naphtha less than 401° F.** Assumed by EIA to be 5.248 million Btu per barrel, equal to the thermal conversion factor for special naphthas. See **Special Naphthas**.

**Petrochemical Feedstocks, Other Oils equal to or greater than 401° F.** Assumed by EIA to be 5.825 million Btu per barrel, equal to the thermal conversion factor for distillate fuel oil. See **Distillate Fuel Oil**.

**Petrochemical Feedstocks, Still Gas.** Assumed by EIA to be 6.000 million Btu per barrel, equal to the thermal conversion factor for still gas. See **Still Gas**.

**Petroleum Coke.** EIA adopted the thermal conversion factor of 6.024 million Btu per barrel as reported in Btu per short ton in the Bureau of Mines internal memorandum, “Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950.” The Bureau of Mines calculated this factor by dividing 30.120 million Btu per short ton, as given in the referenced Bureau of Mines internal memorandum, by 5.0 barrels per short ton, as given in the Bureau of Mines Form 6-1300-M and successor EIA forms.

**Petroleum Products, Total Consumption.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed, weighted by the quantity of each petroleum product consumed.

**Petroleum Products, Consumption by Electric Utilities.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed at electric utilities, weighted by the quantity of each petroleum product consumed at electric utilities. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA’s *State Energy Data Report*.

**Petroleum Products, Consumption by Industrial Users.** Calculated annually by EIA as the average of the thermal conversion factors for all



petroleum products consumed in the industrial sector, weighted by the estimated quantity of each petroleum product consumed in the industrial sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Consumption by Residential and Commercial Users.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed by the residential and commercial sector, weighted by the estimated quantity of each petroleum product consumed in the residential and commercial sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Consumption by Transportation Users.** Calculated annually by EIA as the average of the thermal conversion factors for all petroleum products consumed in the transportation sector, weighted by the estimated quantity of each petroleum product consumed in the transportation sector. The quantity of petroleum products consumed is estimated in the State Energy Data System as documented in EIA's *State Energy Data Report*.

**Petroleum Products, Exports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product, weighted by the quantity of each petroleum product exported.

**Petroleum Products, Imports.** Calculated annually by EIA as the average of the thermal conversion factors for each petroleum product imported, weighted by the quantity of each petroleum product imported.

**Plant Condensate.** Estimated to be 5.418 million Btu per barrel by EIA from data provided by McClanahan Consultants, Inc., Houston, Texas.

**Propane.** EIA adopted the Bureau of Mines thermal conversion factor of 3.836 million Btu per barrel as published in the *California Oil World and Petroleum Industry*, First Issue, April 1942.

**Residual Fuel Oil.** EIA adopted the thermal conversion factor of 6.287 million Btu per barrel as reported in the Bureau of Mines internal memorandum, "Bureau of Mines Standard Average Heating Values of Various Fuels, Adopted January 3, 1950."

**Road Oil.** EIA adopted the Bureau of Mines thermal conversion factor of 6.636 million Btu per barrel, which was assumed to be equal to that of asphalt (see **Asphalt**) and was first published by the Bureau of Mines in the *Petroleum Statement, Annual, 1970*.

**Special Naphthas.** EIA adopted the Bureau of Mines thermal conversion factor of 5.248 million Btu per barrel, which was assumed to be equal to that of the total gasoline (aviation and motor) factor and was first published in the *Petroleum Statement, Annual, 1970*.

**Still Gas.** EIA adopted the Bureau of Mines estimated thermal conversion factor of 6.000 million Btu per barrel, first published in the *Petroleum Statement, Annual, 1970*.

**Unfinished Oils.** EIA assumed the thermal conversion factor to be 5.825 million Btu per barrel or equal to that for distillate fuel (see **Distillate Fuel Oil**) and first published it in EIA's *Annual Report to Congress, Volume 3, 1977*.

**Unfractionated Stream.** EIA assumed the thermal conversion factor to be 5.418 million Btu per barrel or equal to that for plant condensate (see **Plant Condensate**) and first published it in EIA's *Annual Report to Congress, Volume 2, 1981*.

**Waxes.** EIA adopted the thermal conversion factor of 5.537 million Btu per barrel as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*.

## Approximate Heat Content of Natural Gas

**Natural Gas, Total Consumption.** • 1949-1962: EIA adopted the thermal conversion factor of 1,035 Btu per cubic foot as estimated by the Bureau of Mines and first published in the *Petroleum Statement, Annual, 1956*. • 1963-1979: EIA adopted the thermal conversion factor calculated annually by the American Gas Association (AGA) and published in *Gas Facts*, an AGA annual publication. • 1980 forward: Calculated annually by EIA by dividing the total heat content of natural gas consumed by the total quantity of natural gas consumed.

**Natural Gas, Consumption by Electric Utilities.** Calculated annually by EIA by dividing the total heat content of natural gas received at electric

utilities by the total quantity received at electric utilities. The heat contents and receipts are from Form FERC-423 and predecessor forms.

**Natural Gas, Consumption by Sectors Other Than Electric Utilities.**

Calculated annually by EIA by dividing the heat content of all natural gas consumed less the heat content of natural gas consumed at electric utilities by the quantity of all natural gas consumed less the quantity of natural gas consumed at electric utilities. Data are from Forms EIA-176, FERC-423, EIA-759, and predecessor forms.

**Natural Gas, Exports.** • 1949-1972: Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. (See Natural Gas, Total Consumption). • 1973 forward: Calculated annually by EIA by dividing the heat content of exported natural gas by the quantity of natural gas exported, both reported on Form FPC-14.

**Natural Gas Imports.** • 1949-1972: Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. See **Natural Gas, Total Consumption.** • 1973 forward: Calculated annually by EIA by dividing the heat content of imported natural gas by the quantity of natural gas imported, both reported on Form FPC-14.

**Natural Gas, Production (Dry).** Assumed by EIA to be equal to the thermal conversion factor for the consumption of dry natural gas. See **Natural Gas, Total Consumption.**

**Natural Gas, Production, Marketed (Wet).** Calculated annually by EIA by adding the heat content of natural gas, dry production, and the total heat content of natural gas plant liquids production and dividing this sum by the total quantity of marketed (wet) natural gas production.

## Approximate Heat Content of Coal and Coal Coke

**Coal, Total Consumption.** Calculated annually by EIA by dividing the sum of the heat content of coal (including anthracite culm and waste coal) consumption by the total tonnage.

**Coal, Consumption by Electric Utilities.** Calculated annually by EIA by dividing the sum of the heat content of coal (including anthracite culm and waste coal) received at electric utilities by the sum of the total tonnage received.

**Coal, Consumption by Other Power Producers.** Calculated annually by dividing the total heat content of coal (including anthracite culm and waste coal) consumed by other power producers by their total consumption tonnage.

**Coal, Consumption by the Electric Power Sector.** Calculated annually by dividing the total heat content of coal (including anthracite culm and waste coal) by total consumption tonnage of the electric power sector.

**Coal, Consumption by End-Use Sectors.** Calculated annually by EIA by dividing the sum of the heat content of coal (including anthracite culm and waste coal) consumed by the end-use sectors by the sum of the total tonnage.

**Coal, Exports.** Calculated annually by EIA by dividing the sum of the heat content of coal exported by the sum of the total tonnage.

**Coal, Imports.** Calculated annually by EIA by dividing the sum of the heat content of coal imported by the sum of the total tonnage.

**Coal, Production.** Calculated annually by EIA by dividing the sum of the total heat content of coal (including some anthracite culm) produced by the sum of the total tonnage.

**Coal Coke, Imports and Exports.** EIA adopted the Bureau of Mines estimate of 24.800 million Btu per short ton.

## Approximate Heat Rates for Electricity

**Fossil-Fueled Steam-Electric Plant Generation.** There is no generally accepted practice for measuring the thermal conversion rates for power plants that generate electricity from hydroelectric, wood and waste, wind, photovoltaic, or solar thermal energy sources. Therefore, EIA used data from Form EIA-767, "Steam-Electric Plant Operation and Design Report," to calculate a rate factor that is equal to the prevailing annual average heat rate factor for fossil-fueled steam-electric power plants in the United States. By using that factor, it is possible to evaluate fossil fuel requirements for replacing those sources during periods of interruption, such as droughts. The heat content of a kilowatthour of electricity produced, regardless of the generation process, is 3,412 Btu. • 1949-1955: The weighted annual average heat rate for fossil-fueled steam-electric power

plants in the United States, as published by EIA in *Thermal-Electric Plant Construction Cost and Annual Production Expenses—1981* and *Steam-Electric Plant Construction Cost and Annual Production Expenses—1978*. • 1956-1988: The weighted annual average heat rate for fossil-fueled steam-electric power plants in the United States, as published in EIA, *Electric Plant Cost and Power Production Expenses 1991*, Table 9. • 1989 forward: Unpublished factors calculated on the basis of data from Form EIA-767, “Steam-Electric Plant Operation and Design Report.”

**Geothermal Energy Plant Generation.** • 1960-1981: Calculated annually by EIA by weighting the annual average heat rates of operating geothermal units by the installed nameplate capacities as reported on Form FPC-12, “Power System Statement.” • 1982 forward: Estimated annually by EIA on the basis of an informal survey of relevant plants.

**Nuclear Steam-Electric Plant Generation.** • 1957-1991: Calculated annually by dividing the total heat content consumed in nuclear generating units by the total (net) electricity generated by nuclear generating units. The heat content and electricity generation are reported on Form FERC-1, “Annual Report of Major Electric Utilities, Licensees, and Others”; Form EIA-412, “Annual Report of Public Electric Utilities”; and predecessor forms. The factors, beginning with 1982 data, are published in the following EIA reports—1982: *Historical Plant Cost and Annual Production Expenses for Selected Electric Plants 1982*, page 215. 1983-1991: *Electric Plant Cost and Power Production Expenses 1991*, Table 13. 1992 forward: Calculated annually by EIA by dividing the total heat content of the steam leaving the nuclear generating units to generate electricity by the total (net) electricity generated by nuclear generating units. The heat content and electricity generation data are reported in Nuclear Regulatory Commission, *Licensed Operating Reactors—Status Summary Report*, Appendix B.



## Appendix B

### Metric and Other Physical Conversion Factors

Data presented in the *Annual Energy Review* and in other Energy Information Administration publications are expressed predominately in units that historically have been used in the United States, such as British thermal units, barrels, cubic feet, and short tons. However, because U.S. commerce involves other nations, most of which use metric units of measure, the U.S. Government is committed to the transition to the metric system, as stated in the Metric Conversion Act of 1975 (Public Law 94-168), amended by the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418), and Executive Order 12770 of July 25, 1991.

The metric conversion factors presented in Table B1 can be used to calculate the metric-unit equivalents of values expressed in U.S. customary units. For

example, 500 short tons is the equivalent of 453.6 metric tons (500 short tons x 0.9071847 metric tons/short ton = 453.6 metric tons).

In the metric system of weights and measures, the names of multiples and subdivisions of any unit may be derived by combining the name of the unit with prefixes, such as deka, hecto, and kilo, meaning, respectively, 10, 100, 1,000, and deci, centi, and milli, meaning, respectively, one-tenth, one-hundredth, and one-thousandth. Common metric prefixes can be found in Table B2.

The conversion factors presented in Table B3 can be used to calculate equivalents in various physical units commonly used in energy analyses. For example, 10 barrels is the equivalent of 420 U.S. gallons (10 barrels x 42 gallons/barrel = 420 gallons).

**Table B1. Metric Conversion Factors**

U.S. Unit	<i>multiplied by</i>	Conversion Factor	<i>equals</i>	Metric Unit	U.S. Unit	<i>multiplied by</i>	Conversion Factor	<i>equals</i>	Metric Unit
<b>Mass</b>					<b>Volume</b>				
short tons (2,000 lb)	x	0.907 184 7	=	metric tons (t)	barrels of oil (bbl)	x	0.158 987 3	=	cubic meters (m <sup>3</sup> )
long tons	x	1.016 047	=	metric tons (t)	cubic yards (yd <sup>3</sup> )	x	0.764 555	=	cubic meters (m <sup>3</sup> )
pounds (lb)	x	0.453 592 37 <sup>a</sup>	=	kilograms (kg)	cubic feet (ft <sup>3</sup> )	x	0.028 316 85	=	cubic meters (m <sup>3</sup> )
pounds uranium oxide (lb U <sub>3</sub> O <sub>8</sub> )	x	0.384 647 <sup>b</sup>	=	kilograms uranium (kgU)	U.S. gallons (gal)	x	3.785 412	=	liters (L)
ounces, avoirdupois (avdp oz)	x	28.349 52	=	grams (g)	ounces, fluid (fl oz)	x	29.573 53	=	milliliters (mL)
					cubic inches (in <sup>3</sup> )	x	16.387 06	=	milliliters (mL)
<b>Length</b>					<b>Area</b>				
miles (mi)	x	1.609 344 <sup>a</sup>	=	kilometers (km)	acres	x	0.404 69	=	hectares (ha)
yards (yd)	x	0.914 4 <sup>a</sup>	=	meters (m)	square miles (mi <sup>2</sup> )	x	2.589 988	=	square kilometers (km <sup>2</sup> )
feet (ft)	x	0.304 8 <sup>a</sup>	=	meters (m)	square yards (yd <sup>2</sup> )	x	0.836 127 4	=	square meters (m <sup>2</sup> )
inches (in)	x	2.54 <sup>a</sup>	=	centimeters (cm)	square feet (ft <sup>2</sup> )	x	0.092 903 04 <sup>a</sup>	=	square meters (m <sup>2</sup> )
					square inches (in <sup>2</sup> )	x	6.451 6 <sup>a</sup>	=	square centimeters (cm <sup>2</sup> )
<b>Energy</b>					<b>Temperature</b>				
British Thermal Units (Btu)	x	1,055.055 852 62 <sup>a,c</sup>	=	joules (J)	degrees	x	5/9 (after	=	degrees
calories (cal)	x	4.186 8 <sup>a</sup>	=	joules (J)	Fahrenheit (°F)		subtracting 32) <sup>a,d</sup>	=	Celsius (°C)
kilowatthours (kWh)	x	3.6 <sup>a</sup>	=	megajoules (MJ)					

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the Energy Information Administration.

<sup>c</sup>The Btu used in this table is the International Table Btu adopted by the Fifth International Conference on Properties of Steam, London, 1956.

<sup>d</sup>To convert degrees Celsius (°C) to degrees Fahrenheit (°F) exactly, multiply by 9/5, then add 32.

Notes: • Spaces have been inserted after every third digit to the right of the decimal for ease of reading. • Most metric units shown belong to the International System of Units (SI), and the liter, hectare, and

metric ton are accepted for use with the SI units. For more information about the SI units, contact Dr. Barry Taylor at Building 221, Room B610, National Institute of Standards and Technology, Gaithersburg, MD 20899, or on telephone number 301-975-4220.

Sources: General Services Administration, Federal Standard 376B, *Preferred Metric Units for General Use by the Federal Government* (Washington, DC, January 27, 1993), pp. 9-11, 13, and 16. National Institute of Standards and Technology, Special Publications 330, 811, and 814. American National Standards Institute/Institute of Electrical and Electronic Engineers, ANSI/IEEE Std. 268-1992, pp. 28 and 29.

**Table B2. Metric Prefixes**

Unit Multiple	Prefix	Symbol	Unit Multiple	Prefix	Symbol
10 <sup>1</sup>	deka	da	10 <sup>-1</sup>	deci	d
10 <sup>2</sup>	hecto	h	10 <sup>-2</sup>	centi	c
10 <sup>3</sup>	kilo	k	10 <sup>-3</sup>	milli	m
10 <sup>6</sup>	mega	M	10 <sup>-6</sup>	micro	μ
10 <sup>9</sup>	giga	G	10 <sup>-9</sup>	nano	n
10 <sup>12</sup>	tera	T	10 <sup>-12</sup>	pico	p
10 <sup>15</sup>	peta	P	10 <sup>-15</sup>	femto	f
10 <sup>18</sup>	exa	E	10 <sup>-18</sup>	atto	a
10 <sup>21</sup>	zetta	Z	10 <sup>-21</sup>	zepto	z
10 <sup>24</sup>	yotta	Y	10 <sup>-24</sup>	yocto	y

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *The International System of Units (SI)*, NIST Special Publication 330, 1991 Edition (Washington, DC, August 1991), p. 10.

**Table B3. Other Physical Conversion Factors**

Energy Source	Original Unit	multiplied by	Conversion Factor	equals	Final Unit
<b>Petroleum</b>	barrels (bbl)	x	42 <sup>a</sup>	=	U.S. gallons (gal)
<b>Coal</b>	short tons	x	2,000 <sup>a</sup>	=	pounds (lb)
	long tons	x	2,240 <sup>a</sup>	=	pounds (lb)
	metric tons (t)	x	1,000 <sup>a</sup>	=	kilograms (kg)
<b>Wood</b>	cords (cd)	x	1.25 <sup>b</sup>	=	short tons
	cords (cd)	x	128 <sup>a</sup>	=	cubic feet (ft <sup>3</sup> )

<sup>a</sup>Exact conversion.

<sup>b</sup>Calculated by the Energy Information Administration.

Source: U.S. Department of Commerce, National Institute of Standards and Technology, *Specifications, Tolerances and Other Technical Requirements for Weighing and Measuring Devices*, NIST Handbook 44, 1994 Edition (Washington, DC, October 1993), pp. B-10, C-17, and C-21.





# Appendix C

## Carbon Dioxide Emission Factors for Coal

Table C1 presents U.S. average carbon dioxide emission factors for coal by sector. The factors measure the emissions produced during the combustion of coal and were derived by the Energy Information Administration (EIA) from 5,426 sample analyses in EIA's Coal Analysis File. The factors are ratios of the carbon dioxide emitted to the heat content of the coal burned, assuming complete combustion. Factors vary according to the rank and geographic origin of the coal. Sectoral factors reflect the rank and origin of the coal consumed in the sector. Factors differ among sectors and within a sector over time for several reasons:

1. A higher average emission factor in the residential and commercial sector can be attributed to the steady consumption of bituminous coal and anthracite (presumably for home heating).

2. Virtually all of the coal consumed by coke plants comes from only a few States in the Appalachian Coal Basin (West Virginia, Virginia, and eastern Kentucky). Hence, the emission factors for this sector have remained fairly constant.

3. Other industrial users of coal (not coke plants) increased consumption of low-rank, high-emission western coals, which has contributed to a rise in their average emission factor.

4. Electric utilities, which account for most U.S. coal consumption, have shifted over time away from high-rank, low-emission bituminous coal to low-rank, high-emission subbituminous coal and lignite as reflected in a gradually rising weighted-average carbon dioxide emission factor.

**Table C1. Average Carbon Dioxide Emission Factors for Coal by Sector, 1980-1997**  
(Pounds of Carbon Dioxide per Million Btu)

Year	Residential and Commercial	Industrial		Electric Utilities	U.S. Average <sup>b</sup>
		Coke Plants <sup>a</sup>	Other Coal		
1980	210.6	205.8	205.9	206.7	206.5
1981	212.0	205.8	205.9	206.9	206.7
1982	210.4	205.7	206.0	207.0	206.9
1983	209.2	205.5	205.9	207.1	207.0
1984	209.5	205.6	206.2	207.1	207.0
1985	209.3	205.6	206.4	207.3	207.1
1986	209.2	205.4	206.5	207.3	207.1
1987	209.4	205.2	206.4	207.3	207.2
1988	209.1	205.3	206.4	207.6	207.3
1989	209.7	205.3	206.6	207.5	207.3
1990	209.5	206.2	206.8	207.6	207.4
1991	210.2	206.2	206.9	207.7	207.5
1992	211.2	206.2	207.1	207.7	207.6
1993	209.9	206.2	207.0	207.8	207.7
1994	209.8	206.3	207.2	207.9	207.8
1995	210.2	206.4	207.2	208.1	207.9
1996	209.5	206.5	207.0	208.1	208.0
1997	210.2	206.6	207.2	208.2	208.0

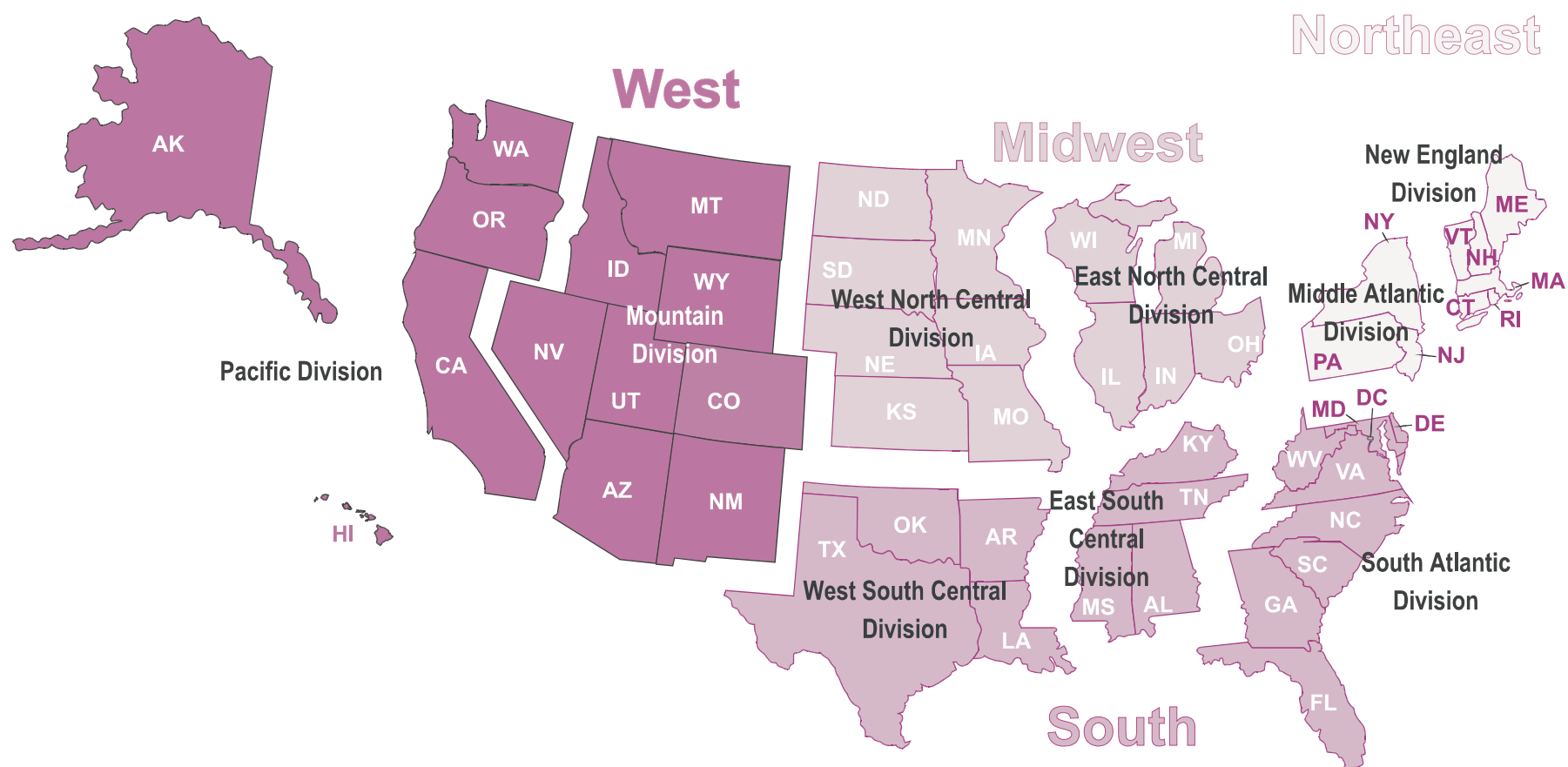
<sup>a</sup>No allowances have been made for carbon-related non-energy coal chemical by-products from the coal carbonization process.

<sup>b</sup>Weighted average. The weights used are consumption values by sector.  
Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.



## Appendix D

### U.S. Census Regions and Divisions



Note: Map not to scale.

Source: Adapted from U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1999* (Washington, DC, October 1999), Figure 1.



# Appendix E

**Table E1. U.S. Gross Domestic Product and Implicit Price Deflator; U.S. and World Population**

Year	U.S. Gross Domestic Product (billion chained (1996) dollars)	U.S. Gross Domestic Product Implicit Price Deflator <sup>1</sup> (1996 = 1.0000)	U.S. Population <sup>2</sup> (million people)	World Population (million people)
1949	R1,550.9	R0.1726	148.7	NA
1950	R1,686.6	R0.1745	151.3	2,556.0
1951	R1,815.1	R0.1871	154.0	2,593.8
1952	R1,887.3	R0.1900	156.4	2,635.8
1953	R1,973.9	R0.1925	159.0	2,681.1
1954	R1,960.5	R0.1944	161.9	2,729.0
1955	R2,099.5	R0.1978	165.1	2,780.3
1956	R2,141.1	R0.2045	168.1	2,833.2
1957	R2,183.9	R0.2113	171.2	2,888.9
1958	R2,162.8	R0.2164	174.1	2,945.3
1959	R2,319.0	R0.2188	177.1	2,997.5
1960	R2,376.7	R0.2219	179.3	3,039.5
1961	R2,432.0	R0.2244	183.0	3,080.1
1962	R2,578.9	R0.2274	185.7	3,136.1
1963	R2,690.4	R0.2300	188.4	3,205.5
1964	R2,846.5	R0.2334	191.1	3,276.5
1965	R3,028.5	R0.2378	193.5	3,345.4
1966	R3,227.5	R0.2446	195.5	3,415.5
1967	R3,308.3	R0.2521	197.4	3,485.2
1968	R3,466.1	R0.2630	199.3	3,556.9
1969	R3,571.4	R0.2759	201.3	3,631.4
1970	R3,578.0	R0.2906	203.3	3,706.6
1971	R3,697.7	R0.3052	206.8	3,784.0
1972	R3,898.4	R0.3182	209.3	3,860.7
1973	R4,123.4	R0.3360	211.4	3,937.1
1974	R4,099.0	R0.3662	213.3	4,012.8
1975	R4,084.4	R0.4003	215.5	4,086.3
1976	R4,311.7	R0.4230	217.6	4,158.3
1977	R4,511.8	R0.4502	219.8	4,230.7
1978	R4,760.6	R0.4823	222.1	4,302.9
1979	R4,912.1	R0.5225	224.6	4,378.1
1980	R4,900.9	R0.5704	226.5	4,453.8
1981	R5,021.0	R0.6237	229.5	4,529.9
1982	R4,919.3	R0.6625	231.7	4,610.2
1983	R5,132.3	R0.6888	233.8	4,690.5
1984	R5,505.2	R0.7144	235.8	4,769.9
1985	R5,717.1	R0.7369	237.9	4,850.6
1986	R5,912.4	R0.7531	240.1	4,933.0
1987	R6,113.3	R0.7758	242.3	5,018.5
1988	R6,368.4	R0.8021	244.5	5,104.6
1989	R6,591.8	R0.8327	246.8	5,190.3
1990	R6,707.9	R0.8651	248.8	5,277.0
1991	R6,676.4	R0.8966	R252.2	5,359.4
1992	R6,880.0	R0.9184	255.0	5,441.8
1993	R7,062.6	R0.9405	R257.8	5,522.9
1994	R7,347.7	R0.9601	260.3	5,602.6
1995	R7,543.8	R0.9810	262.8	5,682.4
1996	R7,813.2	R1.0000	265.2	5,760.9
1997	R8,144.8	R1.0191	R267.8	R5,840.6
1998	R8,495.7	R1.0311	R270.2	R5,918.9
1999	8,848.2	1.0461	272.7	5,996.7

<sup>1</sup> See Glossary.

<sup>2</sup> Resident population of the 50 States and the District of Columbia estimated for July 1 of each year, except for the April 1 census count in 1950, 1960, 1970, 1980, and 1990.

R=Revised. NA=Not available.

Note: See "Chained Dollars" in the Glossary.

Web Pages: • <http://www.bea.doc.gov/>. • <http://www.census.gov/>.

Sources: **U.S. Gross Domestic Product and U.S. Gross Domestic Product Implicit Price Deflator:**

• 1949 forward—Department of Commerce (DOC), Bureau of Economic Analysis (BEA), *Survey of Current Business*. **U.S. Population:** • 1949-1989—DOC, U.S. Bureau of the Census, Current Population Reports Series P-25, November 1998. • 1990 forward—Bureau of the Census, State Population Estimates, December 29, 1999. **World Population:** • 1950 forward—DOC, Bureau of the Census, International Database, December 29, 1999.



# Appendix F

**Table F1a. Energy Consumption in the United States, Selected Years, 1635-1945**  
(Quadrillion Btu)

Year	Coal	Natural Gas	Petroleum	Nuclear Electric Power	Hydroelectric Power	Wood
1635	NA	—	—	—	—	(s)
1645	NA	—	—	—	—	0.001
1655	NA	—	—	—	—	0.002
1665	NA	—	—	—	—	0.005
1675	NA	—	—	—	—	0.007
1685	NA	—	—	—	—	0.009
1695	NA	—	—	—	—	0.014
1705	NA	—	—	—	—	0.022
1715	NA	—	—	—	—	0.037
1725	NA	—	—	—	—	0.056
1735	NA	—	—	—	—	0.080
1745	NA	—	—	—	—	0.112
1755	NA	—	—	—	—	0.155
1765	NA	—	—	—	—	0.200
1775	NA	—	—	—	—	0.249
1785	NA	—	—	—	—	0.310
1795	NA	—	—	—	—	0.402
1805	NA	—	—	—	—	0.537
1815	NA	—	—	—	—	0.714
1825	NA	—	—	—	—	0.960
1835	NA	—	—	—	—	1.305
1845	NA	—	—	—	—	1.757
1850	0.219	—	—	—	—	2.138
1855	0.421	—	—	—	—	2.389
1860	0.518	—	0.003	—	—	2.641
1865	0.632	—	0.010	—	—	2.767
1870	1.048	—	0.011	—	—	2.893
1875	1.440	—	0.011	—	—	2.872
1880	2.054	—	0.096	—	—	2.851
1885	2.840	0.082	0.040	—	—	2.683
1890	4.062	0.257	0.156	—	0.022	2.515
1895	4.950	0.147	0.168	—	0.090	2.306
1900	6.841	0.252	0.229	—	0.250	2.015
1905	10.001	0.372	0.610	—	0.386	1.843
1910	12.714	0.540	1.007	—	0.539	1.765
1915	13.294	0.673	1.418	—	0.691	1.688
1920	15.504	0.813	2.676	—	0.775	1.610
1925	14.706	1.191	4.280	—	0.701	1.533
1930	13.639	1.932	5.897	—	0.785	1.455
1935	10.634	1.919	5.675	—	0.831	1.397
1940	12.535	2.665	7.760	—	0.917	1.358
1945	15.972	3.871	10.110	—	1.486	1.261

NA=Not available. — = Not applicable. (s)=Less than 0.0005 quadrillion Btu.

Notes: • No data are available for years not shown. • See end of section for discussion of geographic coverage of data.

Sources: **Coal, Petroleum and Natural Gas, and Hydroelectric Power:** • 1850-1945: *Energy in the American Economy, 1850-1975*, Table VII. **Wood:** • 1635-1845: U.S. Department of Agriculture Circular No. 641, *Fuel Wood Used in the United States 1630-1930*, February 1942. This source estimates fuelwood consumption in cords per decade, which were converted to Btu using the conversion factor of 20 million Btu per cord. The annual average value for each decade was assigned to the fifth year of the decade on the

assumption that annual use was likely to increase during any given decade and the average annual value was more likely to reflect mid-decade yearly consumption than use at either the beginning or end of the decade. Values thus begin at 1635 and are plotted at 10-year intervals. • 1850-1945: *Energy in the American Economy, 1850-1975*, Table VII (see Bibliography). Values are plotted at 5-year intervals. There is a discontinuity in the wood plot between 1945 and 1949 due to changes in definitions. Data through 1945 are for fuelwood only, while thereafter include wood-derived fuel and wood byproducts burned as fuel, such as cord wood, limb wood, spent pulping liquor, pulp waste, wood sludge, hogged fuel, peat, railroad ties, sawdust, wood chips, bark, forest residues, and charcoal.

**Table F1b. Energy Consumption in the United States, 1949-1999**  
(Quadrillion Btu)

Year	Coal	Natural Gas <sup>1</sup>	Petroleum <sup>2</sup>	Nuclear Electric Power	Hydroelectric Power <sup>3</sup>	Wood
1949	11.981	5.145	11.883	0	1.449	1.549
1950	12.347	5.968	13.315	0	1.440	1.562
1951	12.553	7.049	14.428	0	1.454	1.535
1952	11.306	7.550	14.956	0	1.496	1.474
1953	11.373	7.907	15.556	0	1.439	1.419
1954	9.715	8.330	15.839	0	1.388	1.394
1955	11.167	8.998	17.255	0	1.407	1.424
1956	11.350	9.614	17.937	0	1.487	1.416
1957	10.821	10.191	17.932	(s)	1.557	1.334
1958	9.533	10.663	18.527	0.002	1.629	1.323
1959	9.518	11.717	19.323	0.002	1.587	1.353
1960	9.838	12.385	19.919	0.006	1.657	1.320
1961	9.623	12.926	20.216	0.020	1.680	1.295
1962	9.906	13.731	21.049	0.026	1.822	1.300
1963	10.413	14.403	21.701	0.038	1.772	1.323
1964	10.964	15.288	22.301	0.040	1.907	1.337
1965	11.581	15.769	23.246	0.043	2.058	1.335
1966	12.143	16.995	24.401	0.064	2.073	1.369
1967	11.914	17.945	25.284	0.088	2.344	1.340
1968	12.331	19.210	26.979	0.142	2.342	1.419
1969	12.382	20.678	28.338	0.154	2.659	1.440
1970	12.265	21.795	29.521	0.239	2.654	1.429
1971	11.598	22.469	30.561	0.413	2.861	1.430
1972	12.077	22.698	32.947	0.584	2.944	1.501
1973	12.971	22.512	34.840	0.910	3.010	1.527
1974	12.663	21.732	33.455	1.272	3.309	1.538
1975	12.663	19.948	32.731	1.900	3.219	1.497
1976	13.584	20.345	35.175	2.111	3.066	1.711
1977	13.922	19.931	37.122	2.702	2.515	1.837
1978	13.766	20.000	37.965	3.024	3.141	2.036
1979	15.040	20.666	37.123	2.776	3.141	2.150
1980	15.423	20.394	34.202	2.739	3.118	2.483
1981	15.908	19.928	31.931	3.008	3.105	2.495
1982	15.322	18.505	30.232	3.131	3.572	2.477
1983	15.894	17.357	30.054	3.203	3.899	2.639
1984	17.071	18.507	31.051	3.553	3.800	2.629
1985	17.478	17.834	30.922	4.149	3.398	<sup>4</sup> 2.576
1986	17.260	16.708	32.196	4.471	3.446	<sup>4</sup> 2.518
1987	18.008	17.744	32.865	4.906	3.117	2.465
1988	18.846	18.552	34.222	5.661	2.662	<sup>4</sup> 2.552
1989	18.926	19.384	34.211	5.677	2.999	2.635
1990	19.101	19.296	33.553	6.162	3.104	2.188
1991	18.770	19.606	32.845	6.580	3.175	2.188
1992	19.158	20.131	33.527	6.608	2.820	2.288
1993	19.776	20.827	33.841	6.520	3.105	2.226
1994	19.960	21.288	34.670	6.838	2.936	2.314
1995	20.024	22.163	34.553	7.177	3.446	2.418
1996	20.940	22.559	35.757	7.168	3.883	2.465
1997	21.444	22.530	36.266	6.678	3.898	2.348
1998	21.593	21.921	36.934	7.157	3.506	2.346
1999	21.698	22.096	37.706	7.733	3.354	2.832

<sup>1</sup> Includes supplemental gaseous fuels.

<sup>2</sup> Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.

<sup>3</sup> Conventional hydroelectric power and hydroelectric pumped storage (total pumped storage facility production minus energy used for pumping). Through 1988, includes all net imports of electricity. From

1989, includes only the portion of net imports of electricity that is derived from hydroelectric power.

<sup>4</sup> No data were available; therefore values were interpolated.

(s)=Less than 0.0005 quadrillion Btu.

Sources: **Wood:** Table 10.4. **All Other Data:** Table 1.3.



## Geographic Coverage Note

Tables F1a and F1b present estimates of U.S. energy consumption by energy source for a period that begins a century and a half before the original 13 colonies formed a political union and continues through the decades during which the United States was still expanding territorially. The question thus arises, what exactly is meant by “U.S. consumption” of an energy source for those years when the United States did not formally exist or consisted of less territory than is now encompassed by the 50 States and the District of Columbia?

The documents used to assemble the estimates, and (as far as possible) the sources of those documents, were reviewed carefully for clues to geographic coverage. For most energy sources, the extent of coverage expanded more rapidly than the Nation, defined as all the official States and the District of Columbia. Estimates or measurements of consumption of each energy source generally appear to follow settlement patterns. That is, they were made for areas of the continent that were settled enough to have economically significant consumption even though those areas were not to become States for years. The wood data series, for example, begins in 1635 and includes 12 of the original colonies (excepting Georgia), as well as Maine, Vermont, and the area that would become the District of Columbia.

By the time the series reaches 1810, the rest of the continental States are all included, though the last of the lower-48 States to achieve statehood did not do so until 1912. Likewise, the coal data series begins in 1850 but includes consumption in areas, such as Utah and Washington (State), which were significant coal-producing regions but had not yet attained statehood. (Note: No data were available on State-level historical coal consumption. The coal data shown in Table F1a through 1945 describe *apparent* consumption, i.e., production plus imports minus exports. The geographic coverage for coal was therefore based on a tally of coal-producing States listed in various historical issues of *Minerals Yearbook*. It is likely that coal was consumed in States where it was not mined in significant quantities.)

By energy source, the extent of coverage can be summarized as follows:

- **Wood**—All 48 contiguous States and the District of Columbia by 1810; Alaska and Hawaii beginning in 1949.
- **Coal**—35 coal-producing States by 1885.
- **Petroleum and natural gas**—All 48 contiguous States, the District of Columbia, and Alaska by 1885; Hawaii beginning in 1949.
- **Hydroelectric power**—Coverage for 1890 and 1895 is uncertain, but probably the 48 contiguous States and the District of Columbia. Coverage for 1900 through 1945 is the 48 contiguous States, and the District of Columbia; Alaska and Hawaii beginning in 1949.
- **Nuclear electric power**—Coverage is all 50 States and the District of Columbia throughout.

